PFRP

Pelagic Fisheries Research Program

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Honolulu, Hawaii

Tuna Tagging in Hawai'i

Longline tuna landings, mainly of bigeye and yellowfin, in Hawai'i have increased by a factor of three in the last 10 years (1987-1997) and are critical to the continued success of this fleet. In addition, the demand for skipjack has also been slowly but steadily increasing. Unfortunately, we have little knowledge of how the tuna populations that support these fisheries move within the Hawai'i Exclusive Economic Zone (EEZ) or how they connect to the much larger pan-Pacific tuna populations. Tagging is a common method to obtain information about tunas in the wild. A variety of different kinds of tags are used, ranging in complexity from simple pieces of plastic to sophisticated electronic devices. Each of these types of tags provides information about different biological aspects of the fish to which it was applied. Some of the pioneering work on electronic tags has been conducted by scientists from Hawai'i. Tagging in its various guises has provided important information about tunas in Hawai'i. What are some of these results and what might the future hold?

The Basics

Simple dart tags sometimes called "spaghetti" tags are plastic wires fastened to a barbed head. They are inserted into the back muscles of tuna just below the dorsal fin. Each tag has a unique identification number and information telling the finder how to contact the scientists who released the tagged fish. Thousands of tunas mostly skipjack, yellowfin, and bigeye have been tagged and released with these tags in various parts of the Pacific Ocean during the past 40 years. The recaptures from these releases have provided scientists with information to understand how populations of these species move, to estimate mortality rates and to gauge their capacity to sustain exploitation.

The Inter-American Tropical Tuna Commission (IATTC) released thousands of tagged skipjack and yellowfin in the eastern tropical Pacific in the 1960s and 1970s. A few of these skipjack but no yellowfin were recaptured near Hawai'i. The South Pacific Commission (SPC) released 140,000 tagged skipjack throughout the central Pacific Ocean between 1977 and 1980. Although the overall recapture rate was about 4%, none of these fish was recaptured near Hawai'i. Between 1989 and 1991, the SPC tagged and released 99,000 skipjack, 40,000 yellowfin, and 8,000 bigeye throughout the central and western Pacific Ocean (from Indonesia and the Philippines to the Line Islands from 15° S to 15° N). Recapture rates for the more recent study were higher, 12% for skipjack and 11% for yellowfin, reflecting the substantial increase in the fishery since 1982. Very few were recaptured near Hawai'i. Two bigeye, both mature adults tagged in the Gilbert Islands (Kiribati), were recaptured by Honolulu-based longliners. One skipjack, tagged in the Solomon Islands, was also recaptured in Hawai'i. Japanese research and training vessels routinely tag and release skipjack in the western Pacific. Again, few of these fish have been recaptured in Hawai'i. Researchers at the University of Hawai'i are collaborating with scientists from the SPC and Japan in a PFRP-sponsored analysis of the data from these large-scale projects.

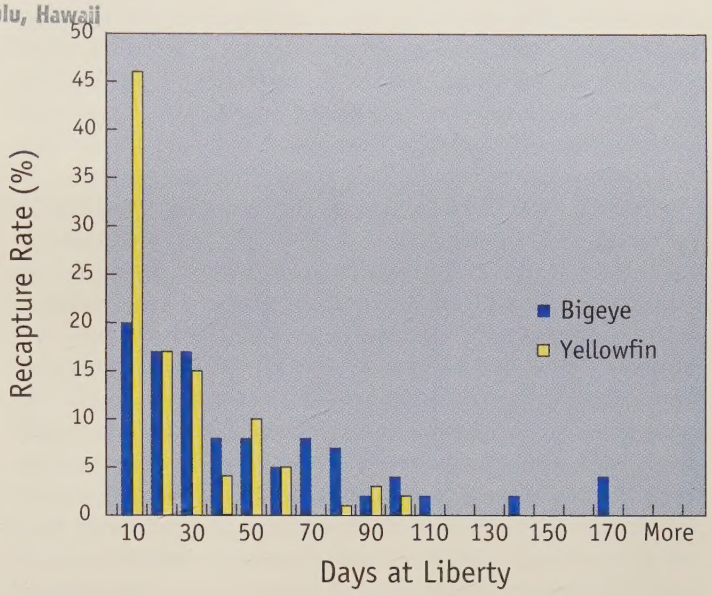

Figure 1. Recapture rates of yellowfin and bigeye tunas tagged and subsequently recaptured at Cross Seamount in relation to period of time at liberty.

Much smaller numbers of tuna have been tagged in Hawaiian waters. The Hawai'i Department of Land and Natural Resources tagged and released 1,900 yellowfin at 14 fish aggregation devices (FADs) from 1985 through 1987. Most of the 233 recaptures (12%) were either at the FAD where the fish were tagged or at other FADs. These results emphasize the importance of FADs to

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the local fishery and suggest that yellowfin reside at FADs for as long as 2 months, reside in the Hawai'i EEZ as long as 15 months and have the ability to navigate directly between FADs.

The National Marine Fisheries Service, Honolulu Laboratory, has been experimenting with tagging mature tunas caught by longline. In many, cases large tuna are landed in good condition by longliners and can be tagged and released. By late 1996, a total of 75 bigeye and 41 yellowfin were tagged by this method from the NOAA research vessel *Townsend Cromwell* and from cooperating commercial longliners. Four bigeye and one yellowfin have been recaptured, all near Hawai'i.

In 1995, PFRP provided funding for the University of Hawai'i to begin a small tagging program to study the population of juvenile bigeye that form the basis of an important fishery at Cross Seamount, southwest of the island of Hawai'i. As of February 1997, approximately 1,600 bigeye and 800 yellowfin had been tagged. Of these, about half were tagged at Cross. The total recaptures are 150 bigeye and 110 yellowfin. Although most were recaptured at Cross, some were recaptured at the NOAA weather buoys and near every one of the main Hawaiian islands. Preliminary results show that yellowfin and bigeye have distinct residence patterns at Cross Seamount with bigeye showing more site fidelity than yellowfin. When the analysis is complete, we will have estimates of residence time of tunas at Cross Seamount and of the relative importance of fishing in the turnover of these fish.

The large-scale tagging projects released many thousands of tagged fish, yet very few were recovered in Hawai'i. There are several possible explanations for the low recapture rate in Hawai'i:

- The distance from the fishing grounds where the fish were tagged to Hawai'i is several thousand miles.
- The mortality rate of juvenile tunas (the size most commonly tagged) is very high, perhaps as high as 40% per month.
- Most tunas are recaptured within a few hundred miles of the place where they were tagged, a result also observed in Hawai'i tagging projects.
- Tag recaptures depend on commercial fisheries, and the intensity of tuna fisheries in Hawai'i was relatively low at the time these projects were conducted.
- The population of tunas in the Pacific is very large and the "concentration" of tags in the general population is very "dilute."

Making Tracks

Acoustic tags are more sophisticated. These devices emit a "beep" that can be detected by a directional underwater microphone (or hydrophone) in a boat. The observer in the boat can follow the signal and thereby track the fish to which the acoustic tag is attached. Additional information, such as swimming depth and body temperature of the fish, can be encoded in the acoustic pulse. Thus the tracking team can accumulate information on the behavior and physiology of the tuna while it is swimming in its natural environment.

In the early 1980s, researchers in Hawai'i used acoustic tracking to show that tunas can navigate directly between FADs and that they may depart from a FAD and return to it the next day. Furthermore, the temperature data from these devices showed that bigeye tunas exert precise control over their body temperature through a combination of physiological control of blood flow through their gills and behavioral control of depth of swimming. These studies are being continued off the Kona coast with PFRP funding and demonstrate that individual tunas may have well defined foraging territories that they patrol daily.

A variant of the acoustic tag transmits a unique identification number that is received by permanently moored recorders that have a range of about 1/4 mile. PFRP funded deployment of these recorders on FADs near Wai'anae and Ka'ena point on the island of O'ahu. Yellowfin tagged with these devices returned repeatedly to the FADs over a period of several months, often apparently in company with the same individuals.

Getting Smart

The next step in electronic tags is the "archival tag." These devices are tiny computers interfaced to sensors that measure ambient light, water pressure, and temperature. The light measurements are used to compute local noon and day length from which longitude and latitude can be estimated with an accuracy of about 1°. The data are stored in a memory chip to be retrieved when the tag is recovered. Unfortunately, these devices are expensive and their application has been confined to fisheries where the chance of recovery is high. They have been used in Australia to track the movements of southern bluefin tuna from Australia westward across the Indian Ocean and back to Australia. They have also been used in Great Britain to monitor the movements of plaice in the tidal currents of the English Channel.

Results of conventional tagging in Hawai'i have shown that the probability of recovering an archival tag from tagged bigeye tuna is sufficiently high. PFRP is sponsoring deployment of archival tags to bigeye in 1997.

PFRP and NMFS Honolulu Laboratory are jointly sponsoring development of a new generation of archival tag in collaboration with scientists from the Commonwealth Scientific and Industrial Research Organization (CSIRO) in Hobart, Australia. These tags will be programmed to detach themselves from the fish after a period of time. They will then rise to the surface of the ocean, "pop-up," and transmit their data to an orbiting satellite. Movements of swordfish, marlins and other large pelagic fish have been difficult to study because of the low return rate of tags applied to these animals. These "pop-up" devices will be applied initially to swordfish and, if successful, will be a very powerful, fishery-independent tool to fill important information gaps.

Future Tagging In Hawai'i

Plans are being developed to extend the Cross experiment to include several other sites in Hawai'i. Results from the expanded tagging program will enable estimation of exchange rates between the different fishing grounds used by Hawai'i fishers and the overall exchange rate of tuna populations between Hawaiian waters and the larger Pacific.

PFRP

Acknowledgments

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The Western Pacific Region: Small Islands, Big Challenges

The American insular Pacific possessions stretch across the tropical Pacific, from Guam and the Northern Marianas to the State of Hawai'i and south to American Samoa, and include Jarvis Island, Howland and Baker Islands, Palmyra Atoll, Kingman Reef, Johnson Island, and Wake Island. Although the land area is limited, the marine Exclusive Economic Zones (from 3 to 200 nautical miles offshore) surrounding these islands total about 1.5 million nmi^2 and represent about half of all EEZ waters under U.S. jurisdiction. Under the Magnuson-Stevens Fisheries Conservation and Management Act, the Western Pacific Regional Fishery Management Council is the policy making organization for the management of fisheries in the EEZs of these American insular possessions.

Although each of the different fishery council regions in the U.S. has its own unique features, none spans as huge an area of ocean nor is more politically diverse than the Western Pacific region, comprising one state, two territories, a commonwealth and seven small islands and atolls of various jurisdiction. Also, unlike the other regions, the Western Pacific has little shelf area and so the greatest volume of commercial fisheries production comes from targeting highly migratory pelagic fishes, particularly tunas and swordfish. Management of these pelagic fisheries requires Council participation at the international level. These pelagic resources are a component of the same stocks in the Western Pacific beyond EEZ waters targeted by fishers from the United States and a number of Asian nations from the western Pacific rim, namely Japan, Korea, Taiwan, the Philippines, Indonesia and increasingly the Republic of China.

Another feature of the Western Pacific that makes it unique in comparison to the other regions is the social and cultural significance of fishing in the lives of the island people. Pre-colonization Polynesian and Micronesian societies were heavily dependent on fish as a source of animal protein; fish, fishing and the sea played a pivotal role forming the culture of these different peoples. Today, even though diets have been altered through the importation of manufactured foods, fish continue to be a large portion of the annual protein intake. Fish consumption in Micronesia and Polynesia averages about 130 lbs/person/yr, and in Hawai'i, fish consumption is twice the U.S. national average of about 90 lbs/person/yr.

Further, although most island people do not need to fish to obtain food, recreational fishing is still an extremely popular pastime and a cultural link with the pre-contact societies. This situation also exists in Hawai'i, where at least one quarter of the population participates in some form of fishing activity at least once per year and the level of community involvement in fishing is higher than in many other U.S. states. Recreational fishing in

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Hawai'i involves not only state residents but also a significant number of the annual 6.6 million tourists who visit the state and want to experience game fishing in the tropical Pacific. This high level of recreational fishing activity is economically important for the state and also of concern to the Council since much of it occurs in waters over which the Council has jurisdiction.

Commercial fishing activity in the Western Pacific region can be broadly divided into two categories: (1) the domestic fisheries in each island where vessels operate within and beyond the EEZ to land fish at their home port and (2) the high seas pelagic fisheries in waters adjacent to the Western Pacific EEZs. Fishing for pelagic species on the high seas is conducted mainly by longliners and purse seiners from countries on the Pacific rim. In general the high seas fisheries are conducted with large (>100-foot) ocean-going fishing vessels and with a high degree of mechanization. The domestic commercial fisheries employ more modest (20- to 70-foot), less mechanized vessels, with even most of the Hawai'i-based longline fleet being under 75 feet in length.

Domestic commercial pelagic fisheries within the Western Pacific region are the most developed in Hawai'i. Until the latter quarter of this century, much of the commercial pelagic catch was skipjack taken by live bait pole-and-line vessels, which supplied a local tuna cannery. This method of fishing has largely declined following the closure of the cannery in 1984, although a small amount of skipjack is still landed for fresh consumption. The predominant pelagic fisheries in Hawai'i are handlining (palu-'ahi and ika-shibi), trolling and longline fishing. Of these methods, by far the most important in terms of volume and value is the longline fishery. Less than 15 longline fishing vessels were active in the early 1980s in Hawai'i, but this fishery, targeting swordfish and tunas, expanded to about 150 vessels by the early 1990s. Hawai'i-based longliners account for about two-thirds of U.S. swordfish production and 15% of all Pacific swordfish landings.

The two methods of handline fishing both target tunas. Palu-'ahi is a day fishery that targets yellowfin and skipjack tuna on seamounts and around FADs off the island of Hawai'i. Ika-shibi is a night handline fishery in which squid are first attracted to the fishing vessel using lights and then are caught and used for bait to catch bigeye, yellowfin and albacore tuna. Trolling, which may

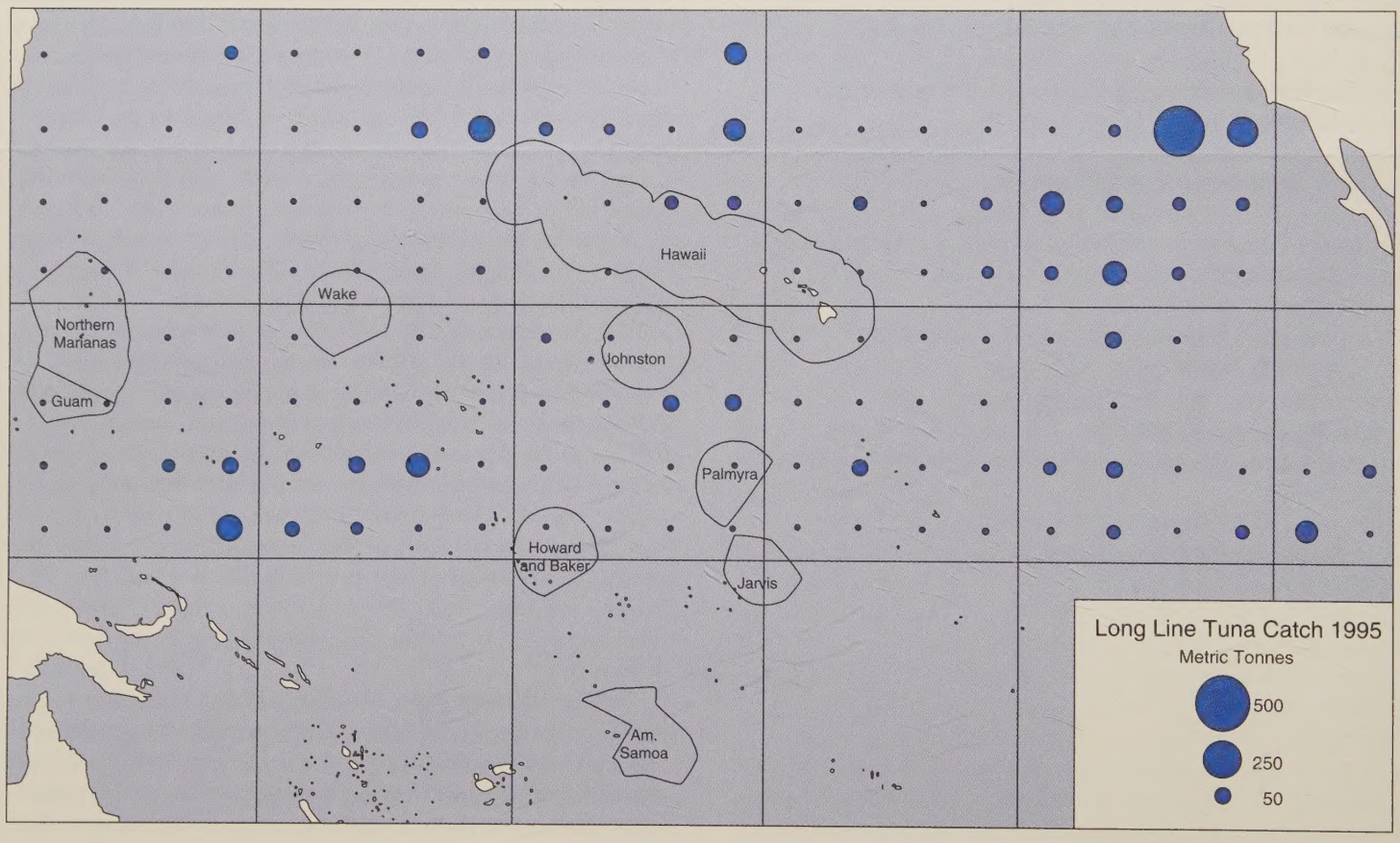

Figure 2. Geographic distribution of total longline catches of tuna in 1995 in the area served by the Western Pacific Regional Fishery Management Council. Total tuna catches are summed over all species of tuna and all nationalities and classes of longline vessels. The size of the circles is proportional to the catch. Data summarized by gear, 5° geographic square, and month were supplied by the South Pacific Commission. Special thanks to PFRP researcher Kevin Weng of the University of Hawai'i Department of Oceanography for preparing this map.

catch a variety of pelagic species, is predominantly a "recreational" fishery; however, there are a few commercial troll fishers in Hawai'i, and pelagic handline and bottomfish fishers may also set trolling lines when traveling to and from fishing grounds to augment their catch. Trolling continues to be the most commonly practiced method for commercial fishers targeting large pelagics in Guam, the Northern Marianas and American Samoa, although longline fishing, principally for albacore, has increased in American Samoa during 1994 and 1995 by vessels based in this territory.

Total commercial fish catches in Hawai'i amounted to about 31 million pounds in 1995, of which pelagic fish formed 97% of the landed volume. Honolulu is only a minor port in terms of landed volume, being ranked 35th overall in the U.S., but is the 9th most important port in terms of catch value. In Guam and the Marianas, fleets from distant water fishing nations (DWFNs) transship large volumes of tuna by air and sea, and the value of this transshipment activity is worth in excess of $117 million. Similarly, landings of tuna by DWFN vessels to canneries in American Samoa are worth in excess of $200 million. Annual fleet expenditures by these vessels has been estimated to be worth as much as $122 million in American Samoa and $92 million in Guam.

The scale and complexity of pelagic fisheries in the Western Pacific requires a substantial input of information for effective management by the Western Pacific Council. As stated earlier, due to the highly migratory nature of tunas and billfish, management of these fisheries must by necessity be conducted at both the national and international levels. The Pacific Ocean covers half the Earth's surface, and production of highly migratory species (mainly tropical tunas) exceeds a million metric tons annually, with a value of $1 billion. For these reasons, the Western Pacific Council established the Pelagic Fisheries Research Program

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Upcoming Events

April 21-25, 1997

Western Pacific Regional Fishery Management Council Meeting, Honolulu, HI; WPRFMC
(808) 522-8220

May 19-22, 1997

48th Annual Tuna Conference
Lake Arrowhead, CA; Inter-American Tropical Tuna Commission
(619) 546-7045

June 15-18, 1997

16th Annual North American Resource Modeling Association Meeting
Seattle, WA; Fisheries Research Institute
rayh@fish.washington.edu

June 25-July 2, 1997

Annual Meeting of the American Society of Ichthyologists and Herpetologists
Seattle, WA

August 24-28, 1997

127th Annual Meeting of the American Fisheries Society
Monterey, CA; American Fisheries Society
(301) 897-8616

October 8-11, 1997

International Symposium on Fisheries Stock Assessment Models for the 21st Century: Combining Multiple Information Sources, 15th Lowell Wakefield Symposium
Anchorage, AK; Alaska Sea Grant College Program
(907) 474-6701

October 25-27, 1997

INFOFISH-TUNA 97
Bangkok, Thailand; INFOFISH
603-291-4466

Western Pacific (continued from page 5)

in 1992 to provide answers to management questions concerning the principal stocks in this region.

The various projects conducted by PFRP reflect the need to focus on both the large and small scales when considering the management of highly migratory pelagic fishes in the Western Pacific region and adjacent waters. Climatic and environmental events such as the El Niño-Southern Oscillation (ENSO) in the Pacific can have major spatial and temporal impacts on tuna populations and fisheries. Studies of the spatial distribution of tunas and the relationships between tuna and their environment are typical of the macro-scale projects conducted by PFRP. At the finer scale, PFRP conducts local projects on socio-economic aspects of fishing operations and fishing communities in Hawai'i, Guam, the Northern Mariana Islands and American Samoa. Further studies focus on the biology and ecology of target species, such as yellowfin tuna (*Thunnus albacares*), and species that may offer new fishery potential, such as the red squid (*Ommastrephes bartrammi*).

The various species that are the targets of fisheries in this region are also studied by other fisheries agencies and research institutions in the Pacific, such as the South Pacific Commission's Offshore Fisheries Program, the Inter-American Tropical Tuna Commission and the Japanese Far Seas Fisheries Research Laboratory. The establishment of PFRP created opportunities for collaboration and sharing of results on tuna and billfish stocks in the tropical Pacific. All of these institutions have been involved in major mark and recapture (tagging) of tunas, which is one of the principal sources of information on spatial distribution, abundance and productivity. A small-scale tagging project is in progress in Hawai'i to investigate residence times of yellowfin and bigeye stocks on an offshore seamount fished by Hawai'i-based longline and handline fishers. Contingent on funding, this project may be expanded to consider the wider question of the degree of interchange of tuna populations between Hawai'i and the eastern and western central Pacific, which at present remains largely unknown.

The re-authorization of the Magnuson Act in 1996 included provisions to permit American Samoa, Guam and the Mariana Islands to negotiate fishery agreements with DWFNs to allow access to their EEZ waters. One requirement of these Pacific Insular Fishing Agreements is the estimation of the total allowable level of foreign fishing (TALFF). Establishing TALFF for pelagic stocks such as tuna and billfish can be extremely problematic, given the extent of the fishing area, the spatial and temporal variability of the stocks, the highly migratory nature of the species involved and the degree of interaction with other pelagic fisheries in the Pacific. These are the kinds of issues that will need to be addressed by PFRP in the future to assist the Western Pacific Council in its responsibility for managing these important fisheries.

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